Application Guide for Model 175

including Programming Guide for IEEE-488 (GPIB) Systems

Introduction

The Keithley Model 175 contains many advanced features that make it suitable for applications requiring more expensive or additional instruments. The purpose of this booklet is to help you determine the suitability of the Model 175 for your application.

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Basic 4½-Digit DMM Performance

The Keithley Model 175 has the functions, ranges, and accuracies you expect in an instrument of its type.

Condensed Specifications

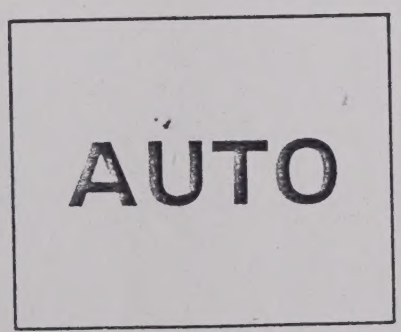
Function	Ranges	Resolution	Accuracy
DC Volts	200mV-1000V	10μV	0.03% Rdg
AC Volts	200mV-750V	10μV	0.5% Rdg
DC Amps	200μA-10A	10nA	0.15% Rdg
AC Amps	100μA-10A	10nA	1.0% Rdg
Ohms	200Ω-200MΩ	10mΩ	0.05% Rdg

(These condensed specifications are for most ranges. See current catalog, data sheet, or instruction manual for more detailed specifications.)

Below are some of the Model 175's additional basic capabilities. Other DMMs you are now using or considering may not have these features.

AUTORANGING

In addition to easy manual range selection, the DCV, ACV, and ohms functions can autorange. Microprocessor design changes ranges FAST so the autoranging is virtually "transparent" to the user.



300kHz TRMS BANDWIDTH

With specified accuracy to 100kHz and useable response to 300kHz, the Model 175 can be used in applications well beyond the audio range. True RMS response eliminates errors due to non-sinusoidal waveforms.

200MΩ RANGE

For measurements above 200kΩ, push the MΩ button. This allows the Model 175 to automatically select the 2MΩ, 20MΩ or 200MΩ range. Alternately, if the AUTO button is pressed, the Model 175 will select the range from 200Ω to 200MΩ.

1000MΩ INPUT IMPEDANCE

On DCV, the 200mV and 2V ranges can be operated with a very high input impedance by releasing all function buttons.

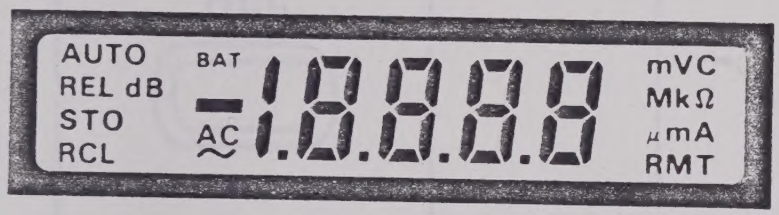
RECHARGEABLE BATTERY OPTION

Can be added to the Model 175 at the factory or in the field.

TRUE DIODE TEST

On the ohms function, push BOTH buttons marked with a diode symbol (→|←). The Model 175 will then measure the forward voltage drop across a diode at a test current of 0.7mA.

Display Annunciators —What They Mean



To make the Model 175 as "user friendly" as possible, a liquid crystal display (LCD) is used. The following annunciators are displayed on the LCD:

AUTO—Indicates that the Model 175 is in Autorange mode.

REL—Indicates relative mode selected—reading is relative to some previous reading.

dB—Decibel mode. Reading is directly in dB or dBm.

STO—Indicates Data Logger and MIN/MAX Hold is engaged. Displayed reading is present input.

RCL—Indicates that displayed reading is recalled data.

BAT—Indicates that battery needs recharging (operates only if battery pack option, Model 1758, is installed).

AC—AC selected (DC implied by absence of AC annunciator).

mV or V—Millovolts or volts selected. Read measurement directly from display, (e.g. 172.3mV).

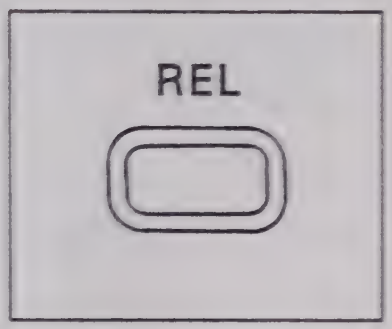
Ω, kΩ or MΩ—Ohms, kilohms or megohms selected. Read measurement directly from display, (e.g. 1.202MΩ).

μA, mA or A—Microamps, milliamps or amps selected. Read measurement directly from display, (e.g. 8.33A).

RMT—(Remote) Model 175 being controlled over the IEEE-488 Bus (Model 1753 installed).

C—Indicates Model 175 is in Calibration mode.

Relative Function



Push the REL button once while any on-scale reading is imposed and the display will immediately go to zero. The previous displayed value is stored and, as indicated by the REL symbol in the display, all future readings are relative to the previous reading.

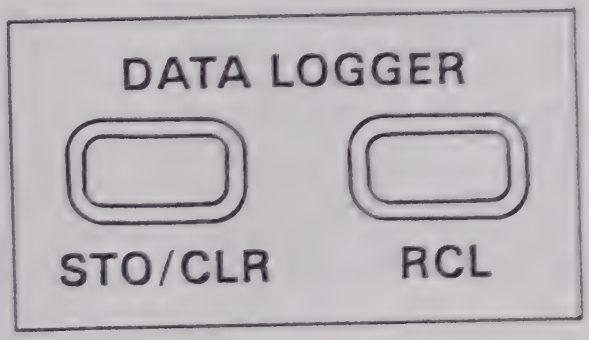
The REL function has many uses. A few examples:

- **Nulling out lead resistance** on low value resistance measurements. *Touch the leads together and push the REL button once.* Future readings will not include lead resistance.

- **Comparing voltages.** Connect the Model 175 to the source or reference voltage and press the REL button. Future readings will show the voltage difference only—such as when you're looking for losses, drifts, or variations.

- **dB measurements.** When used in conjunction with the dB function, stage gains and attenuations can easily be made. While reading the level at one stage, push the REL button. Future readings will show the dB gain or loss relative to the previous reading.

100-Point Data Logger



The Model 175 can store data at one of six selected rates from every reading (3 per second) to 1 reading per hour.

Press and HOLD the STO/CLR pushbutton. The following indicators will scroll on the display, showing the various storage rates.

Display	Indicates Storage Rate
r = 0	every reading
r = 1	1 rdg/sec
r = 2	1 rdg/10 sec
r = 3	1 rdg/min
r = 4	1 rdg/10 min
r = 5	1 rdg/hr

Release the STO/CLR pushbutton when the desired storage rate is displayed. The STO annunciator will turn on and the data will be logged at the selected rate. The Model 175 will continue to operate normally as well, with the display showing the input present.

Press the STO/CLR button to stop the data logger. (A flashing RCL annunciator indicates when 100 readings have been stored.) The data is retained as long as the instrument remains on.

To recall the data:

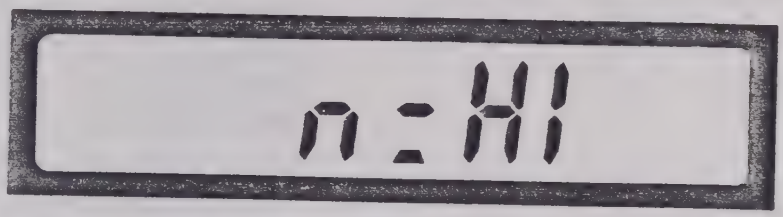
A. Press and HOLD the RCL pushbutton. The display will indicate and scroll through the data points. The first data point displayed will be on the last stored reading (e.g., n = 75 indicates 75th rdg). The next two data points will be the HI and LO readings made during that logging cycle, followed by the first, second, third, etc. data point. Notice that the longer the RCL pushbutton is held in, the faster the data points will scroll on the display. The scroll sequence is continuous and repeatable so data points can be accessed repeatedly.

B. Release the RCL pushbutton at the desired data point and note the reading (data) on the display. The data recall can be incremented in steps of one by momentarily holding in the RCL pushbutton.

Normal (on-line) operation of the display is returned by pressing the STO/CLR pushbutton once. All stored data will still be retained unless the STO/CLR button is pressed again, starting a new store cycle. As long as a new store cycle has not been started, the previous data can be recalled by pressing the RCL button.

NOTE: THE DATA LOGGER CAN BE USED IN THE FIELD UNDER BATTERY PACK POWER (WITH BATTERY OPTION—MODEL 1758—INSTALLED).

MIN/MAX Hold



The MIN/MAX Hold feature of the Model 175 is activated through the DATA LOGGER buttons and is, in fact, engaged whenever the DATA LOGGER is used.

The MIN/MAX Hold is independent of the data logger. It detects and holds the highest and lowest readings *independent of the storage rate* and continues to detect and hold the highest and lowest reading, *even after* the data logger is filled with 100 data points.

To activate the MIN/MAX Hold, press the STO/CLR button once. The STO annunciator on the display will come on, indicating that the Model 175 is now detecting and storing the minimum and maximum readings. Normal operation continues, and the display shows the present input.

To recall the maximum reading, press and HOLD the RCL button briefly until the display shows n=HI then release. The display reading is the highest reading measured.

Press the RCL button and hold it briefly until it steps from n=HI to n=LO then release. The displayed reading is the lowest reading.

Press the STO/CLR button once to put the Model 175 back to normal operation with the display indicating present input. Press the STO/CLR button again to store new minimum and maximum readings.

dB/REL dB Function

The Model 175 is particularly suitable for many audio and communications applications due to its direct reading dB function and extended bandwidth.

dBm—Press the dB button and the Model 175 reads directly in dBm (decibels above or below one milliwatt), with a standard reference impedance of 600Ω. The Model 175 covers a wide dynamic range from −58 to +59.8 dBm on ACV and −98 to +62 on DCV.

Autoranging—Although manual ranging can be used, we suggest taking advantage of the Model 175's autoranging when making dB measurements. This allows you to cover the full 118dB dynamic range without touching the controls, and eliminates inaccuracies caused by selecting the wrong range.

Other Impedances—The REL button allows direct reading dBm measurements with other reference impedances. Simply apply the appropriate voltage (see the manual for correct reference voltage for various impedances) to the input and press the REL button to store the new reference level.

REL dB—Use of the REL and dB functions together also allows dBW measurements and dB voltage measurements, independent of impedance. Direct measurement of stage gains and losses in dB are easy, too, with the dB and REL function. While measuring the dB level of one stage, press the REL button. Future readings are direct dB gains or losses relative to the the previous stage.

RF Measurements—Using our accessory rf probe (Model 1682A) with the dB and REL function, direct dB gain/loss measurements up to 250mHz are easily made.

IEEE-488/System Applications—With the IEEE-488 interface (option 1753) installed, the Model 175 becomes a system dB meter. The REL and dB functions, as well as the range (including autorange), are controllable on the IEEE-488 (GPIB) bus.

Digital Calibration

Whether you have a highly automated or a manual calibration department, the Model 175's digital calibration method offers very significant benefits in simplicity, speed, repeatability and reliability.

NO POTS—No potentiometer adjustments are involved in calibrating the Model 175. All calibration factors for each range are stored in a non-volatile RAM. With no troublesome potentiometers to tweak, repeatable calibration right to the last digit is fast and easy.

TRY IT

An internal jumper prevents alteration of the permanently stored calibration. (Note: Be sure this jumper has not been moved.)

Press and HOLD the dB and REL buttons simultaneously until the display shows "CAL" as shown above. Release the buttons and the display returns to normal except that the "C" annunciator on the upper right corner of the display indicates that the Model 175 is in the calibration mode.

Apply a convenient voltage such as a 1.5V or 9V battery to the appropriate range. (Actual calibration, of course, would use appropriate NBS traceable standards.) Push and HOLD either the left or right Data Logger button to increment the display up or down to the exact reading you want.

Actual calibration would involve repeating these steps for each of the volts and ohms ranges, followed by one additional step (after moving the internal jumper), to lock the new calibration into permanent, non-volatile RAM.

To return to normal operation, turn the instrument off momentarily, then back on.

IEEE-488 option: Allows you to calibrate on the bus. With the IEEE-488 interface (option 1753) installed, the Model 175 can be calibrated on most automated calibration systems in less than 2 minutes.

IEEE-488 Implementation and Sample Programs

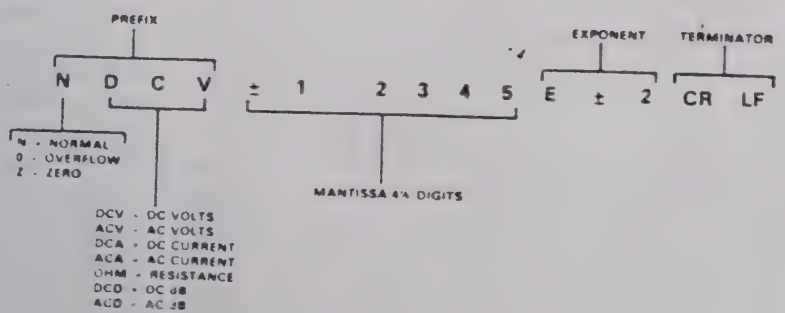
The Keithley Model 175 has an optional IEEE-488 interface (option 1753) which can be included with the instrument or added later. Inclusion of the interface option is evidenced by the connector and address switch at the rear panel. (The field installable option kit includes a replacement top cover with appropriate access openings on the real panel.)

Mode	Command	Description
dB	D0	dB off
	D1	dB on
Range		Volts Ohms
	R0	Auto Auto
	R1	200m 200
	R2	2 2k
	R3	20 20k
	R4	200 200k
	R5	1000 2M
Relative	Z0	REL off
	Z1	REL on
Trigger	T0	Continuous on talk.
	T1	One-shot on talk.
	T2	Continuous on GET.
	T3	One-shot on GET.
	T4	Continuous on X.
	T5	One-shot on X.
EOI	K0	EOI enabled.
	K1	EOI disabled.
Status Word	U0	Output status word.
SRQ Mode	M1	Reading Overflow
	M8	Reading Done
	M9	Reading Done or Reading Overflow
	M16	Busy
	M17	Busy or Reading Overflow
	M24	Busy or Reading Done
	M25	Busy, Reading Done or Reading Overflow

Model	Command	Description
SRQ Mode (continued)	M33 M34 M35 M36 M37 M38 M39	IDDCO IDDC IDDC or IDDCO Not in Remote Not in Remote or IDDCO Not in Remote or IDDC Not in Remote, IDDC or IDDCO
Data Format	G0 G1	Readings with prefix. Readings without prefix.
Digital Calibration	V ± n.nnnnE ± nn	n represents calibration value.
Store	L0	Store Calibration Constants.
Terminator	Y(ASCII) Y(CR LF) Y(LF CR) Y(X)	ASCII character. CR LF LF CR None
Execute	X	Execute other device-dependent commands.

DATA FORMAT:

EXAMPLE
G0 = NDCV − 1,2345E+0
G1 = −1.2345E+0



Programs

The following programs are designed to be a simple aid to the user, and are not intended to suit specific needs. Detailed programming information can be found in the manual.

These programs display one reading at the output of the controller. The program provides an ASCII string variable output of the form:

NDCV+0.0000E+0 CR LF

The note at the end of each program indicates modifications to provide a numeric variable (A) in exponential form:

+0.0000E+0

IBM Personal Computer XT or PC

(National Instruments GPIB-PC)

The following program sends a command string to the Model 175 and displays the reading on the IBM personal computer display. The equipment required for this program is the IBM personal computer XT or PC, the National Instruments GPIB-PC interface and the DOS 2.00 operating system. The GPIB software and hardware must be installed and configured per the National Instruments GPIB-PC instruction manual.

Directions

1. Using rear panel switches, set primary address 24 on the Model 175.
2. Connect the Model 175 to the GPIB-PC interface with power off.
3. Turn on the Model 175 and set to DCV and AUTO range.
4. Type in the command BASIC on the IBM keyboard to get into the IBM interpretive BASIC language.
5. Type in the command LOAD "DECL" to prepare the system for programming. The LOAD "DECL" command takes up the first five lines of the program. Refer to the program.
6. Type in the following program starting with line 10.
7. Type in RUN to execute the program.
8. The display will read "TEST SETUP".
9. To program the Model 175 to the 2V range and take a reading, type in R2T1X and press the return key.
10. The display will read NDCV + 0.0000 E + 0 for "0" volts in. (Short Input)

PROGRAM	COMMENTS
1 CLEAR, 60000! 2 IBINIT=60000! 3 BLOAD "bib.m", IBINIT 4 IBSTA%=0:IBCNT %=0:IBERR%=0 5 CALL IBINIT (IBRD%,IBWRT%, IBCMD%,IBWAIT%,IBRPP%, IBONL%,IBRSC%,IBSIC%, IBSRE%,IBRTL%,IBRSV%, IBLPE%,IBPAD%,IBSAD%, IBIST%,IBDMA%,IBEOS%, IBTMO%,IBEOT%,IBGTS%, IBCAC%,IBDIAG%,IBSTA%, IBERR%,IBCNT%)	The first five lines do not have to be typed in. Typing in LOAD "DECL" accomplishes this task.
10 BD%=0 '	Interface board number is 0.
20 CLS	
30 RD$=SPACE$(25) '	Data buffer = 25 bytes.
40 V%=0 : CALL IBPAD% (BD%,V%) '	Primary address of GPIB is 0.
50 CALL IBSIC%(BD%) '	Interface clear.
60 V%=1 : CALL IBSRE% (BD%,V%) '	Set 175 to remote.
70 CMD$="@8" '	Listen address of 175.
80 INPUT "TEST SETUP"; C$ '	Prompt for command.
90 CALL IBCMD%(BD%,CMD$) '	Address 175 to listen
100 CALL IBWRT%(BD%,C$) '	Send command string to 175.
110 CMD$=" X" '	Talk address of 175
120 CALL IBCMD%(BD%,CMD$) '	Address 175 to talk.
130 CALL IBRD%(BD%,RD$) '	Get data string from 175.
140 PRINT RD$ '	Print data string.
150 GOTO 70 '	Repeat.

IBM Personal Computer XT or PC

(Tecmar IEEE-488 Interface)

The following program sends a command string to the Model 175 and displays the reading on the IBM personal computer display. The equipment required for this program is the IBM personal computer XT or PC, the Tecmar IEEE-488 interface, the Tecmar IEEE-488 software support package (version 1.1) and the DOS 2.00 operating system. The GPIB software and hardware must be installed and configured per the Tecmar IEEE-488 instruction manual.

Directions

1. Using rear panel switches, set primary address to 24 on the Model 175.
2. Connect the Model 175 to the GPIB-PC interface with power off.
3. Set the Model 175 for DCV and AUTO range.
4. Turn computer on with DOS disk installed and enter time and date when prompted.
5. Insert TECMAR disk into drive and type "ASM488". (Press return)
6. Insert DOS disk into drive and type "BASIC". (Press return to get back into the IBM interpretive BASIC language.)
7. Insert TECMAR disk back into drive and type LOAD "IEEESSP". (Press return to enter initialization commands.(Lines 2 through 88 will load into memory.
8. Type in the following program starting with line 100.
9. Type in RUN to execute the program.
10. The display will read "TEST SETUP."
11. To program the Model 175 to the 2V range and take a reading, type in RZT1X an depress the return key.
12. The display will read NDCV + 0.0000 E + 0 for "0" volts in. (Short input)

PROGRAM	COMMENTS
	The first group of lines do not have to be typed in. Typing LOAD "IEEESSP" accomplishes this task.
100 MY.ADDR% = 7:BD. ADDR% = &H310	GPIB ADD. 7 & I/O ADD. FACTORY = 310HEX)
110 CLS	
120 LAD%(0) = 24:LAD%(1) = 199	LISTEN ADD. & ARRAY TER-MINATOR.
130 TAD%(0) = 24:TAD%(1) = 199	TALK ADD. & ARRAY TER-MINATOR.
140 TCIMODE% = 1:MS% = 10	CONFIGURE GPIB FOR INTERRUPTS.
150 TERM% = 2:EOS% = 10: ER% = 0	TERM. SPECIFIER, ASCII EQUIV.(LF), ERROR VAR.
160 DEF SEG = CSEG	CSEG = SEGMENT ADD. OF THE ASM – 488 ROUTINE.
170 CALL INIT%(MS%, TCIMODE%,MY.ADDR%, BD.ADDR%,ER%)	INITIALIZE THE GPIB.
180 ATA$ = SPACE$(25)	DATA BUFFER = 25 BYTES.
190 CALL SDR%(LAD%(0), ER%)	SET REMOTE LINE ACTIVE.
200 STRNUM% = 1	ONE STRING PER READ OR WRITE.
210 INPUT"Test Setup"; BATA$	PROMPT FOR COMMAND.
220 CALL WRSTR% (EOS%, TERM%,LAD%(0),BATA$, STRNUM%,ER%) '	SEND COMMAND TO 175.
230 CALL RDSTR% (EOS%, TERM%,TAD(0),ATA$, STRNUM%,ER%) '	GET DATA FROM 175.
240 PRINT ATA$	PRINT DATA STRING.
250 GOTO 210	REPEAT.

APPLE II (APPLE Interface)

The program below obtains one reading from the Model 175 and displays the reading on the APPLE II screen, using an APPLE IEEE-488 interface.

Directions

1. Set switches on the Model 175 to the addressable mode, primary dress 24.
2. Connect the Model 175 to APPLE II and APPLE IEEE-488 interface.
3. Set the Model 175 to DCV and AUTO range.
4. Enter the program below using the RETURN key after each line.
5. Type in RUN and depress RETURN key.
6. The display will read "TEST SETUP".
7. To program the Model 175 to the 2V range and take a reading, type in R2T1X and depress the RETURN key.
8. Display will read NDCV + 0.0000 E + 0 for "0" volts in. (Short Input)

PROGRAM	COMMENTS
10 DIM A$(20),B$(20)	Dimension data string.
20 Z$=CHR$ (26)	Terminator.
30 INPUT "TEST SETUP?";B$	Enter programming command Example: 2V range = R2T1X
40 PR#3	Send output to IEEE bus.
50 IN#3	Get input from IEEE bus.
60 PRINT "RA"	Turn remote on.
70 PRINT "WT8"; Z$;B$	Write B$ to 175.
80 PRINT "LF1"	Linefeed on.
90 PRINT "RDX";Z$;: INPUT " ";A$	Read data from 175.
100 PRINT "UT"	Untalk.
110 PR#0	Send output to CRT.
120 IN#0	Get input from keyboard.
130 PRINT A$	
140 GOTO 30	Repeat.

NOTE: If conversion to numeric variable is needed, change line 70 line as follows:

134 A=VAL(MID$ (A$,5,11))	Convert string to numeric value.
136 PRINT A	

HP 85

The program below obtains one reading from the Model 175 and displays the reading on the HP 85 CRT screen, using the 82937A GPIB Interface and an I/O ROM.

Directions

1. Set switches on the Model 175 to the addressable mode, primary dress 24.
2. Connect the Model 175 to the HP 82937A IEEE Interface.
3. Set the Model 175 to DCV and AUTO range.
4. Enter the program below using the END LINE key after each line is typed.
5. Depress the RUN key.
6. The display will read "TEST SETUP".
7. To program the Model 175 to the 2V range and take a reading, type in R2T1X and depress the END LINE key.
8. Display will read NDCV + 0.0000 E + 0 for "0" volts in. (Short Input)

PROGRAM	COMMENTS
10 DIM A$[20],B$[20]	Dimension data string
20 REMOTE 724	Set to remote.
30 DISP "TEST SETUP"	Prompt for test setup.
40 INPUT B$	
50 OUTPUT 724; B$	Program the 175.
60 ENTER 724; A$	Get the data from the 175 DMM.
70 DISP A$	
80 GO TO 30	Repeat.
90 END	

NOTE: If conversion to numeric variable is needed, change line 70 line as follows:

70 DISP VAL(A$[5])

PET/CBM 2001

The program below obtains one reading from the Model 175 and displays the reading on the PET/CBM 2001 Series.

Directions

1. Set switches on the Model 175 to addressable mode, primary address 24.
2. Connect the Model 175 to PET/CBM 2001 IEEE interface.
3. Set the Model 175 to DCV and AUTO range.
4. Enter the program below using the RETURN key after each line.
5. Type RUN and depress the RETURN key.
6. The display will read "TEST SETUP".
7. To program the Model 175 to the 2V range and take a reading, type in R2T1X and depress the RETURN key.
8. Display will read NDCV + 0.0000 E + 0 for "0" volts in. (Short Input)

PROGRAM	COMMENTS
10 OPEN 6,24	Open file 6, primary address 24.
20 INPUT "TEST SETUP"; B$	Enter programming command. (Example: 2V DC range = R2T1X.)
30 PRINT#6,B$	Output to the IEEE bus.
40 INPUT#6,A$	Read data from Model 175 via IEEE bus.
50 For N = 1 TO 350	
60 Next N	
70 IF ST=2 THEN 40	If time out, input again.
80 PRINT A$	Print data.
90 GO TO 20	Repeat.

NOTE: If conversion to numeric variable is needed, change line 70 line as follows:

90 A=VAL(MID$(A$,5,15))	Convert string to numeric value.
100 PRINT "A="; A	
110 GO TO 20	Repeat.

Options and Accessories

The Keithley Model 175 has a number of options and accessories that extend it's usefulness and applicability.

OPTIONS:

There are two optional capabilities that can be added internally to the Model 175: an IEEE-488 interface option and a rechargeable battery pack. Either or both of these options can be included in the instrument when purchased and either or both can be field installed later. The options and configurations are as follows:

175	4½-digit Autoranging DMM
175/53	Model 175 with IEEE-488 option installed
175/58	Model 175 with rechargeable battery pack installed
175/53/58	Model 175 with IEEE-488 option and rechargeable battery pack installed
1753	IEEE-488 interface option for Model 175 —field installable
1758	Rechargable battey pack option for Model 175 —field installable

ACCESSORIES:

1010	Single Rack Mounting Kit
1017	Dual Rack Mounting Kit
1301	Temperature Probe (−55 to +150°C)
1600A	High Voltage Probe (40kV
1681	Clip-On Test Lead Set
1682A	RF Probe (250MHz)
1685	Clamp-On Current Probe (200A)
1751	Safety Test Leads
1754	Safety Universal Test Lead Kit
7008-3	IEEE-488 Digital Cable, 0.9m (3 ft.)
7008-6	IEEE-488 Digital Cable, 1.8m (6 ft.)